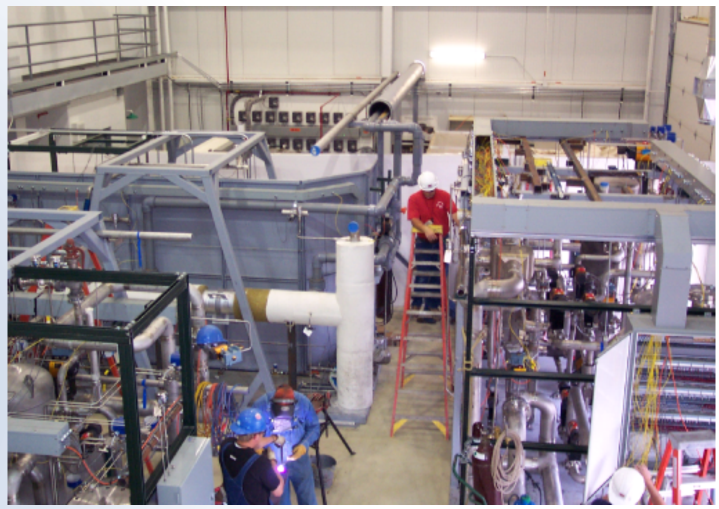
INL's Hydrogen Initiative

This initiative addresses scientific and engineering issues where advancements must be made to realize the potential benefits of a hydrogen economy. It uses INL's portfolio of research and applied engineering capabilities and projects and its significant operations infrastructure – to address this historic priority – as it focuses on hydrogen production, separation, storage and use.

Researching Production and Purification

Currently, most hydrogen is produced by steam reforming of methane in large centralized facilities. This hydrogen production is conducted very efficiently and on a large scale. Future hydrogen production technologies will enable local and regional production and distribution systems. In the long-term, hydrogen will have to be produced without releasing carbon dioxide, and by using feed sources that don't depend on volatile suppliers.



This one-of-a-kind diesel reformer for hydrogen production is undergoing testing at INL.

Diesel Reformer

INL is participating with SOFCo EFS in its 500 kWe Integrated Fuel Processor (IFP) Program, which is part of the Ship Service Fuel Cell Program of the U.S. Navy, to design, fabricate and test a first-generation integrated fuel processor for producing hydrogen-rich gas from NATO-76 fuel. The IFP purifies the hydrogen to the quality needed for proton exchange membrane (PEM) fuel cell operation. The process uses SOFCo EFS's autothermal reforming technology, and when completed, will provide clean electric power on board Navy ships as part of their fuel cell electric power generation system.

Renewable Energy

Hydrogen can also be produced using renewable energy. One method involves biomass gasification. INL is working with a Salt Lake City business – Emery Energy – on their unique gasifier concept that integrates features of entrained flow and fixed-bed gasifiers.

Nuclear Energy

The current growth in hydrogen demand is already sufficient to justify the development of new, environmentally responsible methods to produce hydrogen using nuclear energy. As the transportation sector is revolutionized, the worldwide demand for hydrogen could eventually rival that for electricity. As the lead laboratory for DOE's Office of Nuclear Energy, Science and Technology, INL is ideally positioned for assuming a major role in the development of technologies for the production of hydrogen using nuclear energy. The advantages of using nuclear energy for hydrogen production include decreased or no carbon dioxide emissions, and independence from imported fossil fuels. INL has projects investigating the two most promising methods of using nuclear energy for hydrogen production – high temperature electrolysis, and thermochemical cycles for splitting water into hydrogen and oxygen.

<u>High Temperature Electrolysis</u>

The overall efficiency of electrolysis is increased considerably by performing it at high temperatures. In this process, Solid Oxide Fuel Cell (SOFC) technology will be used with the SOFC unit operated in reverse as an electrolyzer. A new generation of nuclear reactor, the Very High Temperature Reactor (VHTR), will eventually supply

Continued on back

Continued from front

both electricity and high temperature heat to the electrolyzer. Greater efficiency is realized as a significant fraction of the energy input to the electrolyzer is supplied as thermal rather than electrical energy. Also, the use of higher temperatures for electrical generation results in a greater efficiency of the electrical generation step. This project for which Ceramatec, a developer of SOFC technology, is a subcontractor to INL is supported by the Office of Hydrogen, Fuel Cells and Infrastructure Technologies of the Department of Energy Office of Energy Efficiency and Renewable Energy.

Thermochemical Cycles

INL has initiated an internally funded project to address technical barriers to the engineering demonstration of thermochemical cycles for splitting water into hydrogen and oxygen. A number of water splitting cycles have been proposed but these have been demonstrated only at the laboratory scale. All of the cycles require a source of energy – generally significant heat. There are a number of engineering barriers that must be addressed before water-splitting processes can be demonstrated on a large scale. This INL-funded project includes tasks to identify materials that can withstand the high temperatures and corrosive conditions required in many of the thermochemical cycles, develop efficient separation methods for complex chemical mixtures, improve kinetics, and improve the efficiency of electrochemical steps included in some of the cycles. It is envisioned that in the 2015 time frame, a VHTR could be operating at the INL site, integrated with the operation of two or more hydrogen production processes – presumably high temperature electrolysis and one or more thermochemical water splitting cycles. In another project, as a subcontractor to General Atomics, INL is involved in the conceptual design of an integrated nuclear reactor/Sulfur-Iodine cycle for hydrogen production. INL along with other national labs is currently working with the DOE Office of Nuclear Energy, Science and Technology on an R&D plan that will lead to the eventual demonstration of hydrogen production using nuclear energy.

Membrane Separation

In a project funded by DOE Fossil Energy, INL along with team lead ITN Energy Systems (Wheat Ridge, CO) and other team members are working to develop a unique composite membrane structure for high temperature hydrogen separation.

Researching Storage

Impermeable Composite Tank Liner

INL has worked with partner Quantum Technologies and the University of California at Los Angeles on an innovative concept for an electrochemically active liner for conformable composite hydrogen storage tanks to resolve the problem of hydrogen permeation.

Sodium Borohydride Regeneration

An aqueous solution of sodium borohydride allows a safe and convenient means of providing a source of hydrogen on board a vehicle. Millenium Cell, Inc. has developed technology for release of gaseous hydrogen from the borohydride solution. The missing link for this technology is an economical method for the regeneration of borohydride from the borate by product formed in the hydrogen generation step. INL is working on borohydride regeneration with DOE funding.

Carbon Materials

INL has worked on advanced carbon materials (intercalated graphite) to increase the amount of hydrogen that can be stored on a vehicle, since the interior volume of the graphite is made available for hydrogen adsorption.

Researching Hydrogen Infrastructure and Use

Fuel Cell Fabrication

A Bechtel-sponsored Solid Oxide Fuel Cell (SOFC) development project has designed a revolutionary, low-cost, planar SOFC “stack.” The structural framework of this fuel cell stack is largely provided by a unique nickel-aluminide (NiAl) bipolar plate make by combustion synthesis. The electrodes can operate at high temperatures without oxidation of the bipolar plate.

Vehicle Fueling and Testing

The hydrogen fueling station and vehicle testing activities being evaluated by INL are supported by the DOE EERE Advanced Vehicle Testing Activity. Objectives include evaluating the safety and reliability of operating vehicles on hydrogen and blended hydrogen fuels, and evaluating the vehicle/infrastructure interface. Partners include Arizona Public Service (APS) and Electric Transportation Applications Corp. Hydrogen vehicle activities managed by INL include dynamometer, closed track, emissions, and fleet operations testing along with data collection, analysis and dissemination.

For more information

Technical and Management Contact:

John Kolts
208-526-2235
John.Kolts@inl.gov

INL is a U.S. Department of Energy national laboratory operated by Battelle Energy Alliance